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Study on Mechanical and Tribological Properties of Glass Fiber Reinforcedepoxy Composites with Sic & Flyash as Fillers

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Abstract : *Glass fiber reinforced polymer composites are one of the most widely used composite materials due to its light weight and high impact resistance used for aerospace, marine and other industrial applications. Glass fiber used in industrial applications to make polymer matrix composite is having chemical inertness in nature. In this work, a method is proposed to add fly ash and Silicon carbide (Sic) content to polymer matrix for enhancing the overall strength and improve tribological properties of the composite. In this method polymer matrix composites are fabricated by using hand lay-up technique in different weight percentages of fly ash and Sic (5%, 10%, 15%, and 20%).The mechanical properties such as tensile, compression, impact and hardness properties are studied as per ASTM standards. Experimental investigation on Tribological properties of Flyash and silicon carbide reinforced Glass fiber epoxy composites with different weight (0%,5%,10%) percentages using pin-on-disc machine and analysis of tribological characterstics in ANOVA are done in this work.*
Keywords *- Glass fiber, hand lay-up technique ,Silicon carbide, pin-on-disc machine.*

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I. INTRODUCTION

A composite material is made by combining two or more materials are together to create a superior, unique material properties, minimizes their weakness and chemically distinct phases. A composite material is heterogeneous at a microscopic scale but statistically homogeneous at macroscopic scale. The composite materials have significantly different properties. The composites materials can be naturally or artificially made materials. There are many researches for new materials which will satisfy the specific requirements for various applications like aerospace, marine, industrial, structural, electrical, house-hold, etc.

II. TYPES OF COMPOSITE MATERIALS

These three types of matrix produce three common types of composites

Polymer matrix composites (PMCs): Polymer matrix composites are comprised of a variety of short or continuous fibers bound together by an organic polymer matrix. The advantage of PMCs is their light weight coupled with high stiffness and strength along the direction of the reinforcement. This combination is the basis of their usefulness in aircraft, automobiles, and other moving structures.

Metal-matrix composites (MMCs): In metal matrix composites use silicon carbide fibers embedded in a matrix made from an alloy of aluminum and magnesium, but other matrix materials such as titanium, copper, and irons are increasingly being used. Typical applications of MMCs include bicycles, golf clubs, and missile guidance systems.

Ceramic-matrix composites (CMCs): The ceramic matrix makes them particularly suitable for use in lightweight, high-temperature components, such as parts for airplane jet engines .Ceramic matrix composites (CMC) are produced from ceramic fibers embedded in a ceramic matrix. Various ceramic materials, oxide or non-oxide, are used for the fibers and the matrix.

III. APPLICATIONS OF GLASS FIBER

Storage tanks, house hold, piping system, traffic lights, Helicopter rotor blades, surf boards, rowing shells

Introduction of Epoxy Resin

Epoxy resins are polymeric or semi-polymeric materials, and as such rarely exist as pure substances, since variable chain length results from the polymerization reaction used to produce them. High purity grades can be produced for certain applications, e.g. using a distillation purification process. One downside of high purity liquid grades is their tendency to form crystalline solids due to their highly regular structure, which require melting to enable processing. The applications for epoxy-based materials are extensive and include coatings, adhesives and composite materials such as those using carbon fiber and fiber glass reinforcements (although polyester, vinyl ester, and other thermosetting resins are also used for glass-reinforced plastic).

Hardener

Hardener is high viscous liquid material, mixed with resin in suitable proportion during the process of preparation of composites which helps in the solidification of the wet, smooth composite. It is used to harden the smooth composite hence it is called as hardener.

Catalyst

Catalysis is the increase in the rate of a chemical reaction due to the participation of an additional substance called a catalyst. With a catalyst, reactions occur faster and require less activation energy.

Fly ash

Coal-burning power plants that consume pulverized solid fuels produce large amounts of coal ash. These are the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric power generating plant. The coal ash consists of inorganic, incombustible matter present in the coal that has been fused during combustion into a glassy, amorphous structure

IV. FABRICATION PROCESSES

Wet/Hand Lay-Up:

The fibers are first put in place in the mould. The fibers can be in the form of woven, knitted, stitched or bonded fabrics. Then the resin is impregnated. The impregnation of resin is done by using rollers, brushes or a nip-roller type impregnator. The impregnation helps in forcing the resin inside the fabric. The laminates fabricated by this process are then cured under standard atmospheric conditions. The materials that can be used have, in general, no restrictions. One can use combination of resins like epoxy, polyester, vinyl ester, phenolic and any fiber material. Fig 1.1 shows the simple hand layup technique.

Advantages of Hand Lay up:

The process results in low cost tooling with the use of room-temperature cure resins.
The process is simple to use.
Any combination of fibers and matrix materials are used.
Higher fiber contents and longer fiber as compared to other processes.

Disadvantages:

Since the process is worked by hands, there are safety and hazard considerations.
The resin needs to be less viscous so that it can be easily worked by hands.
The quality of the final product is highly skill dependent of the labour.
Uniform distribution of resin inside the fabric is not possible. It leads to voids in the laminates.
Possibility of diluting the contents.

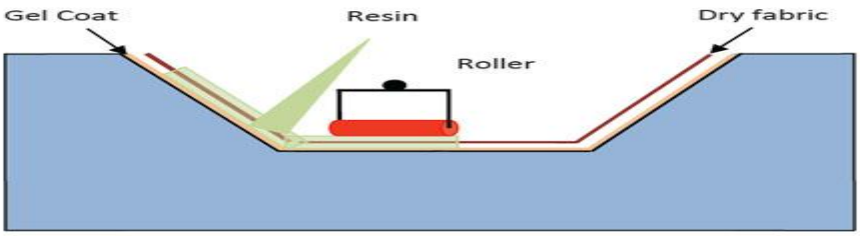


Fig 1.1 HandLay Up Technique

V. APPLICATIONS OF COMPOSITE MATERIALS:

Aerospace: Aircraft, spacecraft, satellites, space telescopes, space shuttle, space station, missiles, and booster's rockets, helicopters (due to high specific strength and stiffness) fatigue life, dimensional stability.
Missile: Rocket motor cases, Nozzles, aerodynamic fairings etc.
Launch vehicle: Inter stage structure, High temperature nozzles, and control surfaces etc.
Composite railway carriers: Bodies of railway bogeys, seats, doors, gear case, pantographs etc.
Sports equipments: Tennis rockets, golf clubs, base-ball bats, helmets etc.
Automotive: Drive shafts, fan blades, clutch plates, gaskets, engine parts etc.
Industrial: conveyer belts, hoses, tear and puncture resistant fabrics, ropes, cables etc.
Medical: Wheel chairs, crutches, Hip joints, surgical equipments etc.

VI. LITERATURE REVIEW

Basavarajappa et al [1] have done their project using the optimization technique Taguchi and perform to acquire data in a controlled way. An orthogonal array and analysis of variance (ANOVA) was employed to investigate the influence of process parameters on the wear in composite materials. Based on Taguchi approach, the experimentation provides an orderly way to collect, analyzes, and interpret data. Incorporation of the silicon carbide particles in the polymer matrix as a secondary Reinforcement increases the wear resistance of composite material. Applied load is the wear factor that has the highest physical as well as statistical influence on the wear of composite material.

B.Suresha et al [2] carried out experimentation to study the influence of two inorganic fillers of SiC particles and graphite on wear of the glass fabric reinforced epoxy composites. They reported that the increase of load and sliding velocity results higher wear loss. The coefficients of frictional values are increasing with increase of load and sliding velocities. By investigation, the Graphite filled glass fiber composite has lower coefficient of friction. Silicon carbide and Graphite filled composites exhibits maximum wear resistance. Inclusion of Graphite and silicon carbide filler particles in Glass fiber composite reduces friction and gives better wear resistance properties.

V. Manikandan1 et al [3] Conducted experimentation to study the influence of fly ash fillers on mechanical and tribological properties of woven jute fiber reinforced polymer hybrid composite. Composites were prepared using hand layup method with weight percentage of fly ash as filler material. Inclusion of Filler percentage increases hardness and wear resistance properties but decreases the tensile strength of composite material decreases.

VII. EXPERIMENTAL DETAILS

Fabrication of Composites

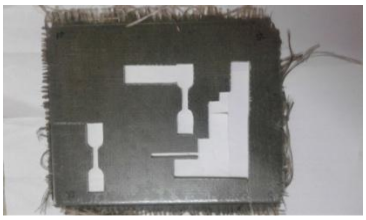
Hand lay-up technique is the simplest and oldest open molding method of composite fabrication process. In this work, Silicon carbide, fly ash powder of different weight percentages (0%,5%,10%,15%,20%) as shown in Fig 3.1 are mixed with epoxy-hardener mixture and fiber reinforcements and filler materials of epoxy mixture are placed manually against the mold surface as shown in Fig3.2.The thickness is controlled by layers placed against the mould. After the preparation of specimens, the work pieces are cured for 24 to 48 hrs so that work pieces will get hard as shown in Fig 3.3. After this, the specimens were cut according to ASTM standards using cutting machine as shown in Fig3.4 and finished the composite material with Emory paper as shown in Fig 3.5. The designations of work pieces are shown in Table 3.1.

Fig 1.2 Mixture of matrix material with varies wt% of fillers Fig 1.3 Fabrication by hand lay-up method

Table 1.1 Designation of work pieces

Material code	Glass Fiber(wt%)	Matrix(wt%)	SiC Filler (wt%)	FlyAsh filler (wt%)
Bare	50	50	0	0
S1	50	45	2.5	2.5
S2	50	40	5	5
S3	50	35	7.5	7.5
S4	50	30	10	10

a



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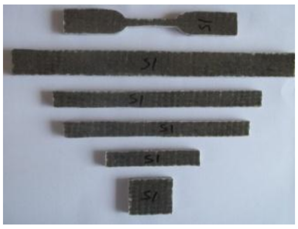


c

Fig 1.4 a. Solidified composite material after curing 48 hours at room temperature
Fig 1.5 b. Cutting of composite material by switch board cutting machine
Fig 1.6 c. Cutting of composite material as per ASTM standards

Fig 1.7 Specimens of S1 composite material for pin-on-disc test

Fig 1.8 Specimens of S2 composite material for pin-on-disc test

VIII. TENSILE TEST

Tensile test is conducted as per ASTM D638 IV standards specimen cut in to $33\times 6 \times 5$.
Tensile test is widely used to find the behavior of material when subjected to a slowly applied tensile load. It is conducted on computerized universal testing machine (UTM).
As per ASTM standard Test specimen of composite material of uniform flat cross-section is gripped in the jaws of machine at the both ends and a pull is exerted axially. The stress-strain curve obtained for composite material.

Table 1.2 Technical specifications for computerized version universal testing machine

MODEL	TUE-C-600
Measuring capacity (KN)	600
Measuring Range (KN)	0-600
Least count (KN)	0.06
Resolution of piston movement(mm)	0.1
Overall dimensions approx(mm)	$2200 \times 800 \times 2400$
Weight approx(kg)	3100
Distance between columns(mm)	600
Piston stroke(mm)	250
Power supply	3 phase 415v 50HZ AC
Total H.P	2.5
Pair of compression plate diameter(mm)	120
Tension test jaws for flat specimen thickness(mm)	0-30
Tension test jaws for Maximum width of flat specimen(mm)	70

IX. COMPRESSIVE TEST

Compression test is conducted as per ASTM D3410 standards specimen cut in to $140\times 12.7\times 3$.Compressive test is conducted on computerized universal testing machine in a similar way as tensile test, but the direction of loading is reversed. Component subjected to a compressive force does not deform uniformly. If the material is plastic instead of brittle, it bulges at its mid-section. In this test stress rises rapidly near the end of the test due to an increase in area of the specimen.

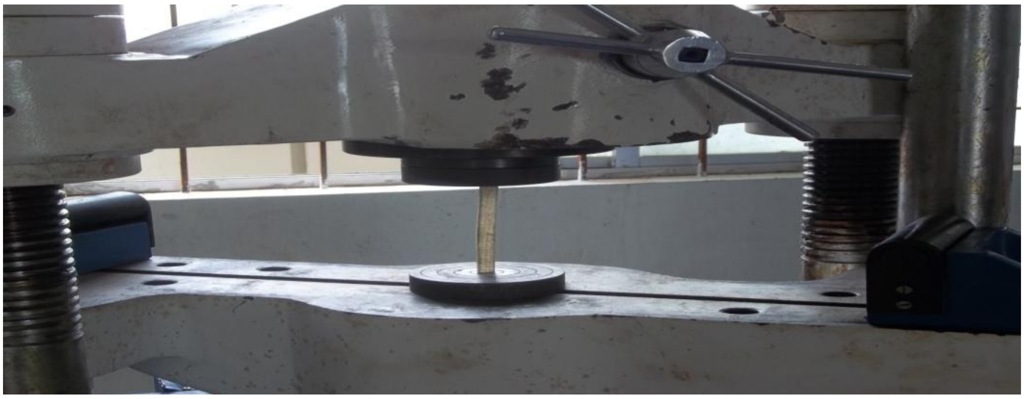


Fig 1.9 Compression Test Rig

X. CALCULATIONS OF MECHANICAL PROPERTIES

Calculation of Tensile modulus

Tensile Modulus (E) = $\frac{\text{Stress}}{\text{Strain}}$

Stress = $\frac{\text{Load at peak (KN)}}{\text{Area of cross -section } (mm^2)}$

Stress for bare material = $\frac{8.52}{6\times5}$

=0.284 N/mm2.

Strain for bare material = $\frac{L_f - L_o}{L_o}$

$= \frac{37-33}{33}$

=0.1212.

Tensile modulus for bare material (E) = $\frac{\text{stress}}{\text{strain}}$

E = $\frac{0.284}{0.1212}$

E = 2343N/mm2

Tensile modulus for S1 material E = 2947.56 N/mm2

Tensile modulus for S2 material E = 3712.50 N/mm2

Tensile modulus for S3 material E = 3094.059 N/mm2

Tensile modulus for S4 material E = 2719.47 N/mm2

XI. EXPERIMENTAL PROCEDURE OF WEAR TEST

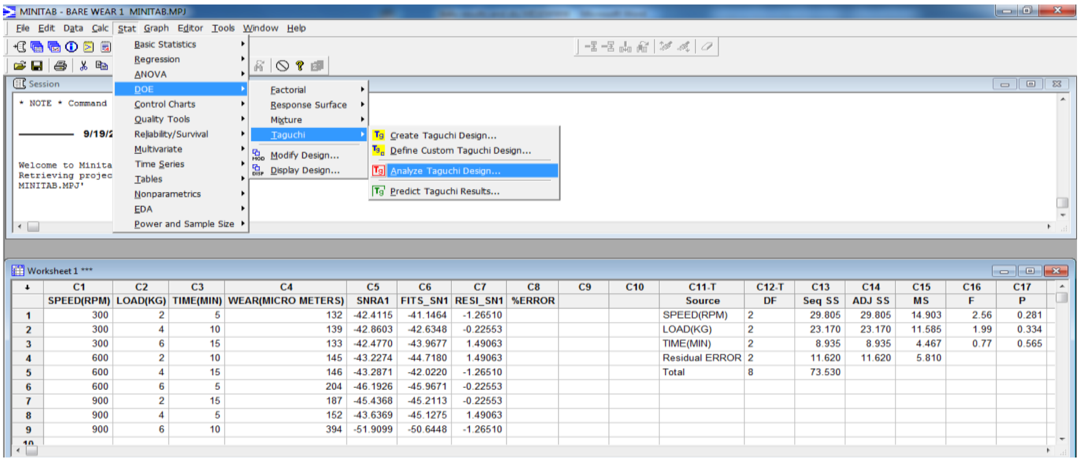
Set wear track radius 35mm Unscrew to loosen sliding plate move it to positioning at 35mm by looking at the graduated scale.

Procedures for wear display loosen LVDT lock screw to bring LVDT Plunger visually to mid position.The wear reading display on controller should be as near to zero. Initialize wear display to zero pressing zero push button on controller.Apply normal load place required weights on loading pan slowly without shaking.Move loading arm away from Friction force load cell button and pressing frictional force zero button.Setting disc speed and set time on controller.Note down the values of wear, Frictional Force, coefficient of friction of varies wt% of composite materials and changing control parameters.

Table 1.3 Experimental results of bare material

SPEED (RPM)	LOAD (KG)	TIME (MIN)	WEAR(MICRO METERS)	FRICTIONAL FORCE (N)	COEFFICIENT OF FRICTION
300	2	5	132	9.1	0.449
300	4	10	139	17.4	0.447
300	6	15	133	20.8	0.343
600	2	10	145	8.1	0.373
600	4	15	146	16	0.35
600	6	5	204	21.9	0.35
900	2	15	187	7.5	0.387
900	4	5	152	12.9	0.304
900	6	10	394	15.1	0.258

The coefficient of friction between surfaces normally increases with increasing temperature and decreasing load. In almost all cases, a lower coefficient of friction will lead to a lower wear rate.



↓	C1 SPEED(RPM)	C2 LOAD(KG)	C3 TIME(MIN)	C4 WEAR(MICRO METERS)	C5 SNRA1	C6 FITS_SN1	C7 RESI_SN1	C8 %ERROR	C9	C10	C11-T Source	C12-T DF	C13 Seq SS	C14 ADJ SS	C15 MS	C16 F	C17 P
1	300	2	5	132	-42.4115	-41.1464	-1.26510				SPEED(RPM)	2	29.805	29.805	14.903	2.56	0.281
2	300	4	10	139	-42.8603	-42.6348	-0.22553				LOAD(KG)	2	23.170	23.170	11.585	1.99	0.334
3	300	6	15	133	-42.4770	-43.9677	1.49063				TIME(MIN)	2	8.935	8.935	4.467	0.77	0.565
4	600	2	10	145	-43.2274	-44.7180	1.49063				Residual ERROR	2	11.620	11.620	5.810		
5	600	4	15	146	-43.2871	-42.0220	-1.26510				Total	8	73.530				
6	600	6	5	204	-46.1926	-45.9671	-0.22553										
7	900	2	15	187	-45.4368	-45.2113	-0.22553										
8	900	4	5	152	-43.6369	-45.1275	1.49063										
9	900	6	10	394	-51.9099	-50.6448	-1.26510										

Fig 1.10 Taguchi Analysis in Mini Tab

XII. RESULTS & DISCUSSIONS

TENSILE TEST RESULTS

Tensile test Report for Bare Material

TENSILE TEST REPORT

Machine Model	TUE-C-600	Test File Name	1602_2016.Utm
Machine Serial No	2014 /65	Date	09/08/2016
Customer Name	K.B.S.S.RAMA KRISHNA	Customer Address	ANITS
Lot No.	8	Test Type	Tensile
Order No	1	Heat No.	

Input Data

Specimen Shape	Flat	
Material Type	E-GLASS FIBER 50%+EPOXY	
Specimen Description		
Specimen Width	6	mm
Specimen Thickness	4	mm
Gauge Length For % Elog.	33	mm
Pre Load Value	0	kN
Max. Load	600	kN
Max. Elongation	250	mm
Specimen Cross Section Area	24	mm2
Final Specimen Width	5	mm
Final Specimen Thickness	3.5	mm
Final Gauge Length	37	mm

Output Data

Load At Yield	3.27	kN
Elongation At Yield	0.000	mm
Yield Stress	136.25	N/mm2
Load At Peak	8.520	kN
Elongation at Peak	3.890	mm
Tensile Strength	355.000	N/mm2
Load At Break	5.130	kN
Elongation At Break	5.890	mm
Breaking Strength	213.750	N/mm2
% Reduction Area	27.08	%
% Elongation	12.12	%

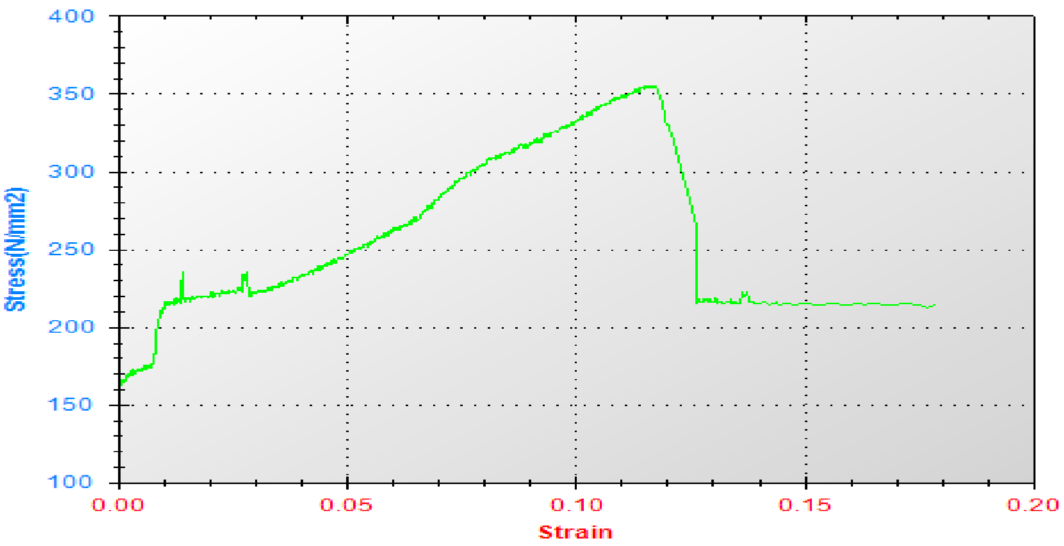


Fig 2.1 Generated Graph of Stress Vs Strain for Bare material

Tensile test Report for S1 Material

TENSILE TEST REPORT

Machine Model	TUE-C-600	Test File Name	1608_2016.Utm
Machine Serial No	2014 /65	Date	09/08/2016
Customer Name	K.B.S.S.RAMA KRISHNA	Customer Address	ANITS
Lot No.		Test Type	Tensile
Order No		Heat No.	

Input Data

Specimen Shape	Flat	
Material Type	E-GLASS 50%+EPOXY RESIN	
Specimen Description	S1	
Specimen Width	6	mm
Specimen Thickness	5	mm
Gauge Length For % Elog.	33	mm
Pre Load Value	0	kN
Max. Load	600	kN
Max. Elongation	250	mm
Specimen Cross Section Area	30	mm2
Final Specimen Width	5	mm
Final Specimen Thickness	4.5	mm
Final Gauge Length	41	mm
Final Area	22.5	mm2

Output Data

Load At Yield	4.89	kN
Elongation At Yield	0.000	mm
Yield Stress	163	N/mm2
Load At Peak	13.470	kN
Elongation at Peak	5.330	mm
Tensile Strength	449.000	N/mm2
Load At Break	6.270	kN
Elongation At Break	5.400	mm
Breaking Strength	209.000	N/mm2
% Reduction Area	25.00	%
% Elongation	24.24	%

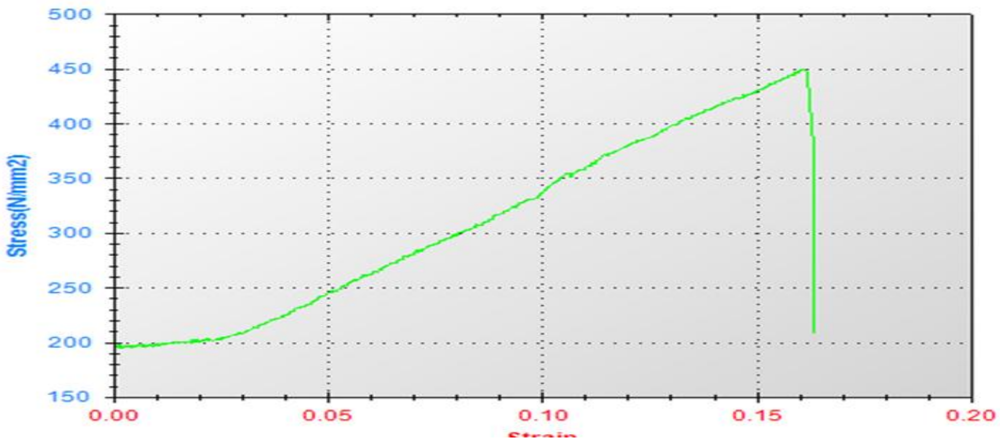


Fig 2.2 Generated Graph of Stress Vs Strain for S1 material

Tensile test Report for S2 Material

TENSILE TEST REPORT

Machine Model	TUE-C-600	Test File Name	1606_2016.Utm
Machine Serial No	2014 /65	Date	09/08/2016
Customer Name	K.B.S.S.RAMA KRISHNA	Customer Address	ANITS
Lot No.		Test Type	Tensile
Order No		Heat No.	

Input Data

Specimen Shape	Flat	
Material Type	E-GLASS 50%+EPOXY RESIN	
Specimen Description	s2	
Specimen Width	6	mm
Specimen Thickness	4	mm
Gauge Length For % Elog.	33	mm
Pre Load Value	0	kN
Max. Load	600	kN
Max. Elongation	250	mm
Specimen Cross Section Area	24	mm2
Final Specimen Width	5.2	mm
Final Specimen Thickness	3.4	mm
Final Gauge Length	36	mm
Final Area	17.68	mm2

Output Data

Load At Yield	5.88	kN
Elongation At Yield	5.780	mm
Yield Stress	245	N/mm2
Load At Peak	10.830	kN
Elongation at Peak	9.670	mm
Tensile Strength	451.250	N/mm2
Load At Break	5.880	kN
Elongation At Break	10.250	mm
Breaking Strength	245.000	N/mm2
% Reduction Area	26.33	%
% Elongation	9.09	%

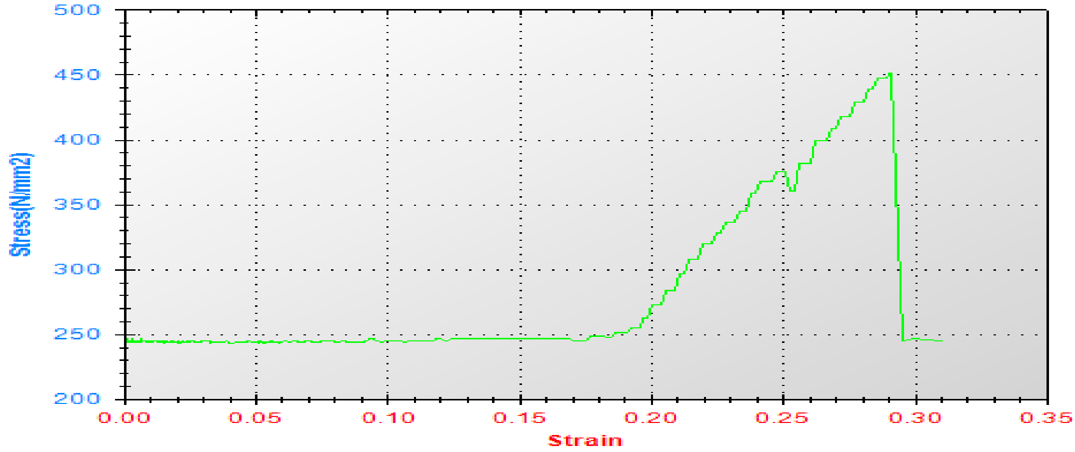


Fig 2.3 Generated Graph of Stress Vs Strain for S2 material

Tensile test Report for S3 Material

TENSILE TEST REPORT

Machine Model	**TUE-C-600**	Test File Name	**1633_2016.Utm**
Machine Serial No	**2014 /65**	Date	**10/08/2016**
Customer Name	**K.B.S.S.RAMA KRISHNA**	Customer Address	**ANITS**
Lot No.		Test Type	**Tensile**
Order No		Heat No.	

Input Data

Specimen Shape	Flat	
Material Type	E-GLASS 50%+EPOXY RESIN	
Specimen Description	S3	
Specimen Width	6	mm
Specimen Thickness	5	mm
Gauge Length For % Elog.	33	mm
Pre Load Value	0	kN
Max. Load	600	kN
Max. Elongation	250	mm
Specimen Cross Section Area	30	mm2
Final Specimen Width	4.3	mm
Final Specimen Thickness	4.1	mm
Final Gauge Length	37	mm
Final Area	17.63	mm2

Output Data

Load At Yield	5.34	kN
Elongation At Yield	0.000	mm
Yield Stress	178	N/mm2
Load At Peak	11.250	kN
Elongation at Peak	3.560	mm
Tensile Strength	375.000	N/mm2
Load At Break	5.820	kN
Elongation At Break	3.780	mm
Breaking Strength	194.000	N/mm2
% Reduction Area	41.23	%
% Elongation	12.12	%

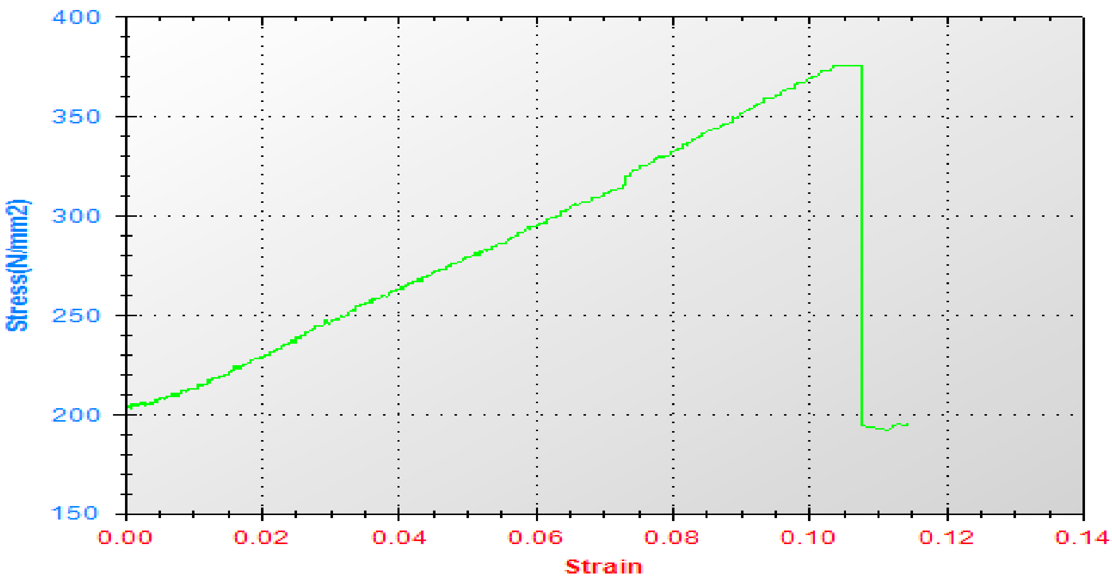


fig 2.4 Generated Graph of Stress Vs Strain for S3 material

Tensile test Report for S4 Material

TENSILE TEST REPORT

Machine Model	TUE-C-600	Test File Name	1626_2016.Utm
Machine Serial No	2014 /65	Date	10/08/2016
Customer Name	K.B.S.S.RAMA KRISHNA	ıstomer Address	15KD1A0301, 302,303
Lot No.		Test Type	Tensile
Order No		Heat No.	

Input Data

Specimen Shape	Flat	
Material Type	E-GLASS 50%+EPOXY RESIN	
Specimen Description	S4	
Specimen Width	6	mm
Specimen Thickness	5	mm
Gauge Length For % Elog.	33	mm
Pre Load Value	0	kN
Max. Load	600	kN
Max. Elongation	250	mm
Specimen Cross Section Area	30	mm2
Final Specimen Width	5.4	mm
Final Specimen Thickness	4.7	mm
Final Gauge Length	38	mm
Final Area	25.38	mm2

Output Data

Load At Yield	4.71	kN
Elongation At Yield	0.000	mm
Yield Stress	157	N/mm2
Load At Peak	12.360	kN
Elongation at Peak	5.810	mm
Tensile Strength	412.000	N/mm2
Load At Break	5.250	kN
Elongation At Break	5.820	mm
Breaking Strength	175.000	N/mm2
% Reduction Area	15.40	%
% Elongation	15.15	%

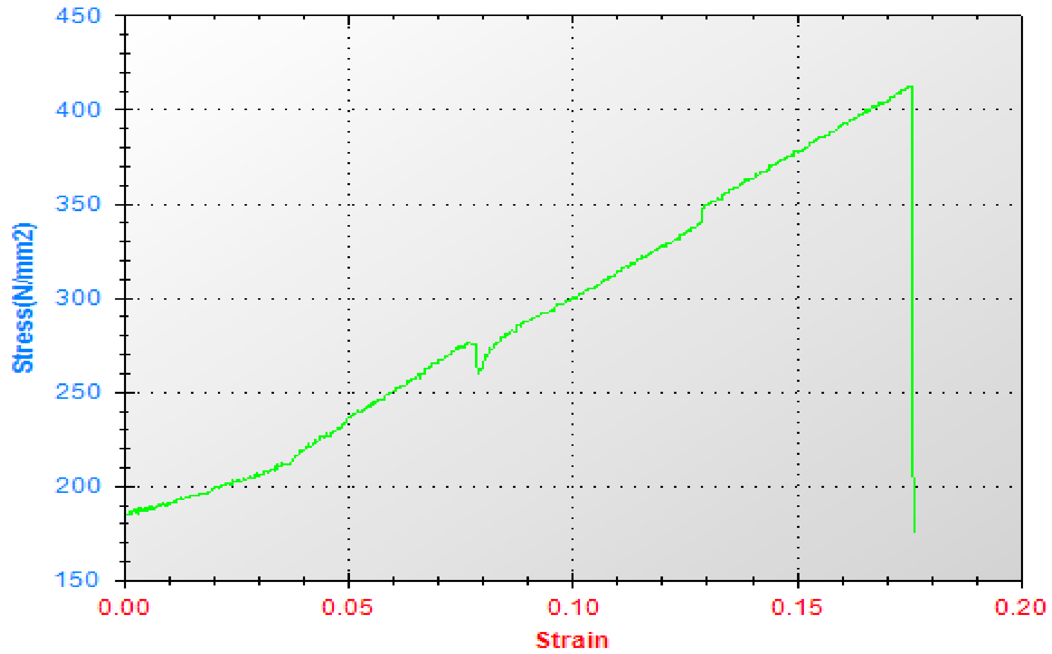


Fig 2.5 Generated Graph of Stress Vs Strain for S4 material

Figs 2.1-2.5 show the tensile test reports and computer generated graphs. It observes from the generate graphs; S2 material has higher tensile strength then other glass fiber composite materials. Table 1.4 and Fig 1.6 below clearly show the variations of tensile strength of various composite materials.

Table 1.4 Tensile Test Comparison Results

MATERIAL	TENSILE STRENTH(N/mm^2)
BARE	355
S1	449
S2	451.25
S3	375
S4	412

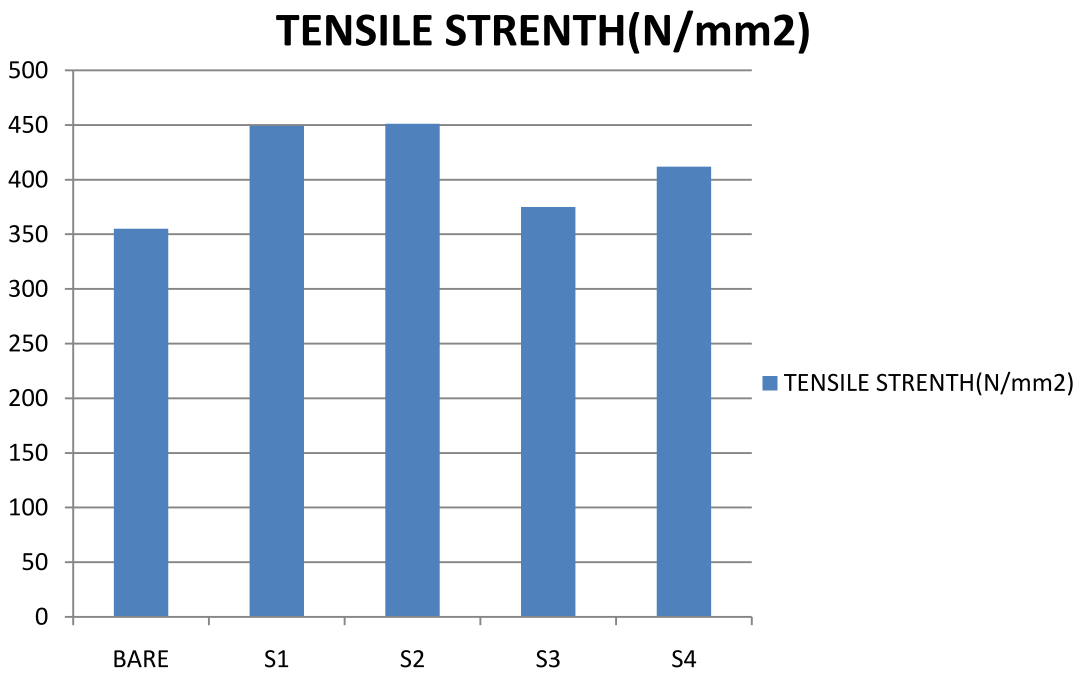


Fig 2.6 Tensile strength comparison graphs of composite materials

COMPRESSION TEST RESULTS

Compression test Report for Bare Material

Compression Test Report

Machine Model	TUE-C-600	Test File Name	1615_2016.Utm
Machine Serial No	2014 /65	Date	09/08/2016
Customer Name	K.B.S.S.RAMA KRISHNA	Customer Address	ANITS
Lot no		Test Type	Compression
Work Order No.		Heat Number	

Input Data

Specimen Shape	Flat	
SpecimenType	E-GLASS FIBER 50%+EPOXY	
Specimen Description		
Specimen Width	14	mm
Specimen Thickness	4	mm
Pre Load Value	0	kN
Max. Load	600	kN
Max. Elongation	250	mm
Specimen Cross Section Area	56	mm2

Output Data

Load at Peak	26.880	kN
Elongation at Peak	0.740	mm
Compression Strength	480.000	N/mm2

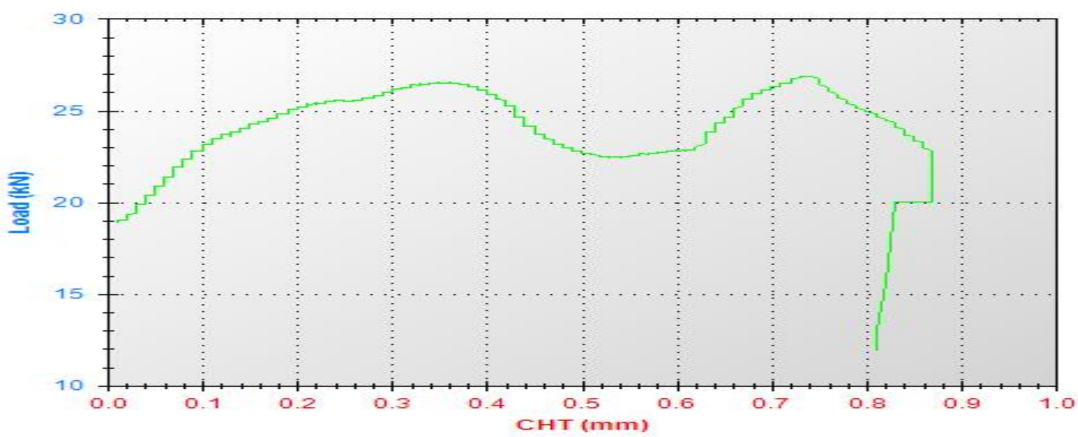


Fig 2.7 Generated Graph of Load Vs Elongation for Bare material

Compression test Report for S1 Material

Compression Test Report

Machine Model	TUE-C-600	Test File Name	1617_2016.Utm
Machine Serial No	2014 /65	Date	09/08/2016
Customer Name	K.B.S.S.RAMA KRISHNA	Customer Address	ANITS
Lot no		Test Type	Compression
Work Order No.		Heat Number	

Input Data

Specimen Shape	Flat	
SpecimenType	E-GLASS 50%+EPOXY RESIN	
Specimen Description	S1	
Specimen Width	14	mm
Specimen Thickness	4	mm
Pre Load Value	0	kN
Max. Load	600	kN
Max. Elongation	250	mm
Specimen Cross Section Area	56	mm2

Output Data

Load at Peak	74.250	kN
Elongation at Peak	1.190	mm
Compression Strength	1325.893	N/mm2

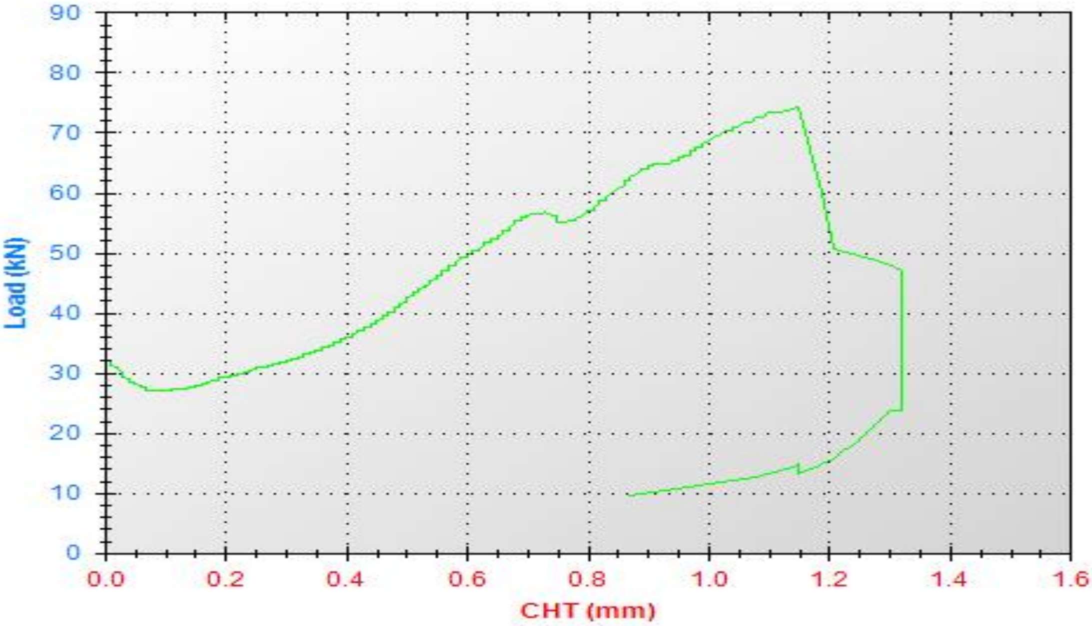


Fig 2.8 Generated Graph of Load Vs Elongation for S1 material

Table 1.5 Mechanical properties of composite materials

Material	Tensile strength (N/mm2)	Tensile modulus (N/mm2)	Compression Strength (N/mm2)	Impact Strength (J/mm2)	Hardness (kgf/mm2)	Surface Roughness (µm)
Bare	355	2343	480	0.1	6.629	1.08
S1	449	2947.56	1325.893	0.128	19.06	0.675
S2	451.25	3712.5	1556.143	0.1428	14.87	0.545
S3	375	3094.06	868.714	0.1714	13.56	0.37
S4	412	2719.47	1086.429	0.2	16.37	0.24

Table 1.5 shows the mechanical properties of various glass fiber reinforced composites. the mechanical properties of various glass fiber reinforced composites. It observes from above graph bare material has higher surface roughness, S1 material has higher hardness, S2 material has higher tensile strength and tensile modulus, finally S4 material has higher impact strengths then other glass fiber composites.

Wear test results

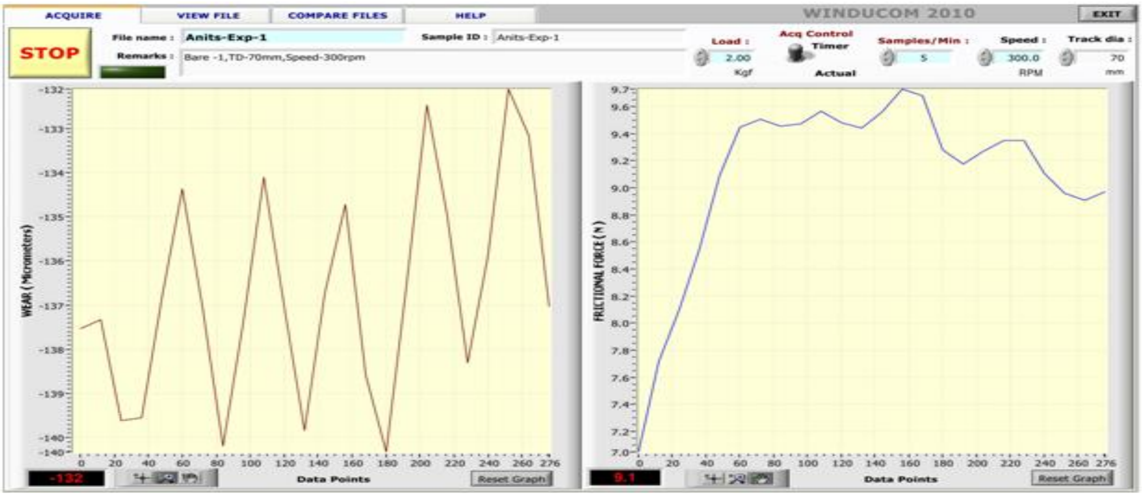


Fig 2.9 Wear rate and Friction Force Acquire for Experiment 1

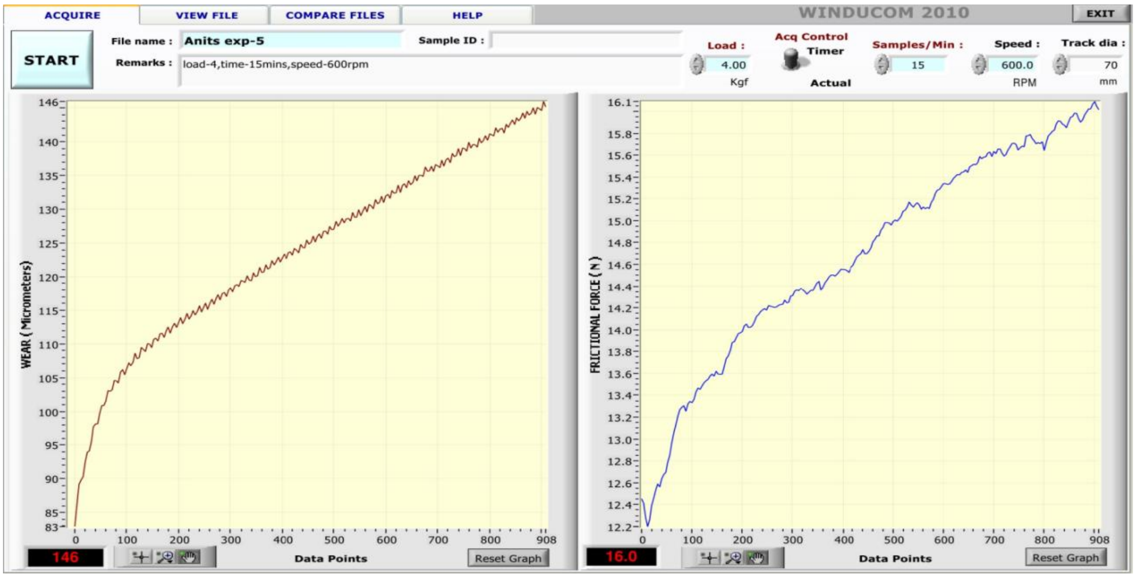


Fig 2.10 Wear rate and Friction Force Acquire for Experiment 5

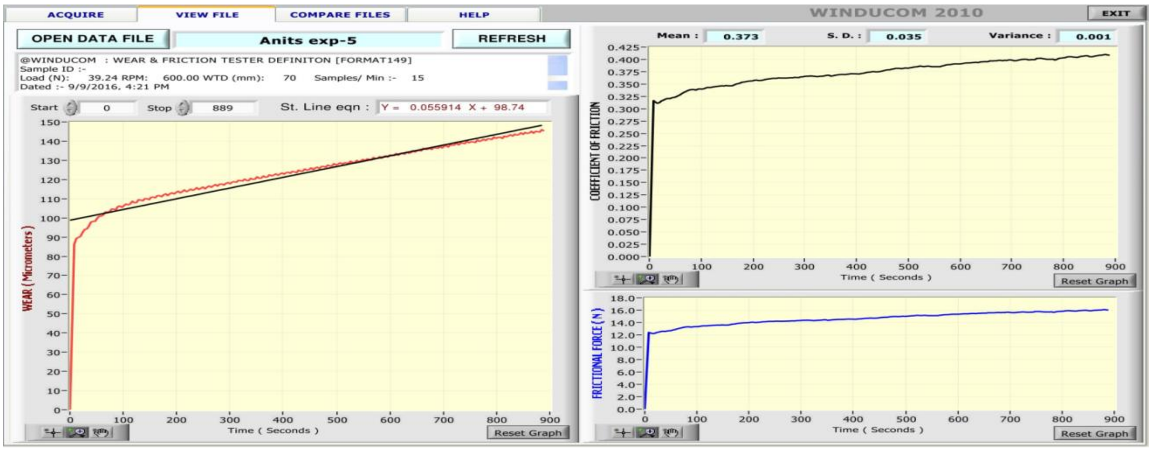


Fig 3.1 Tribological characteristics Vs Time Acquire for Experiment 5

XIII. ANOVA ANALYSIS RESULTS

Table 1.6 L9 (3× 3) Orthogonal Array and analyzed Taguchi Design for Wear in Bare Material

SPEED(RPM)	LOAD(KG)	TIME(MIN)	WEAR(MICRO METERS)	S/N RATIO(db)	FITS_SN1	RESI_SN1	%ERROR
300	2	5	132	-42.4115	-41.1464	-1.2651	2.982917
300	4	10	139	-42.8603	-42.6348	-0.22553	0.526198
300	6	15	133	-42.477	-43.9677	1.49063	-3.50926
600	2	10	145	-43.2274	-44.718	1.49063	-3.44835
600	4	15	146	-43.2871	-42.022	-1.2651	2.92258
600	6	5	204	-46.1926	-45.9671	-0.22553	0.488238
900	2	15	187	-45.4368	-45.2113	-0.22553	0.49636
900	4	5	152	-43.6369	-45.1275	1.49063	-3.41599
900	6	10	394	-51.9099	-50.6448	-1.2651	2.437107

Table 1.7 Analysis of Variance for SN ratios

Source	DoF	Sum of sqaures ss	MS	F	P	Contribution
SPEED(RPM)	2	29.805	14.903	2.56	0.281	40.53448
LOAD(KG)	2	23.17	11.585	1.99	0.334	31.51095
TIME(MIN)	2	8.935	4.467	0.77	0.565	12.1515
Residual ERROR	2	11.62	5.81			15.80307
Total	8	73.53				100

Table 1.8 Response Table for Signal to Noise Ratios Smaller is better

Level	SPEED(RPM)_1	LOAD(KG)_1	TIME(MIN)_1
1	-42.58	-43.69	-44.08
2	-44.24	-43.26	-46
3	-46.99	-46.86	-43.73
Delta	4.41	3.6	2.27
Rank	1	2	3

Table 1.6 show L9 (3× 3) Orthogonal Array and analyzed Taguchi Design for Wear in Bare Material. It can be observed from the results obtained from Table 1.7 that speed was the most significant parameter having the highest statistical influence (40.53%) on the dry sliding wear of composites followed by load (31.51%) and time (12.15%).When the P-value for this model was less than 0.05, then the parameter or interaction can be considered as statistically significant. This is desirable as it demonstrates that the parameter or interaction in the model has a significant effect on the response. From an analysis of the results obtained it is observed that the interaction effect of load & speed is significant influencing wear rate of bare composites. Table 1.8 give rankings to influencing parameters based on these speed is most influencing on wear of bare material.

XIV. CONCLUSION

In this project, Fabrication of various glass fiber reinforced composite materials. The mechanical properties are observed by experimentation on different weight percentages of fly ash and Sic (5%, 10%, and 15% 20%). In mechanical experimental work, results obtained is bare material has higher surface roughness, S1 material has higher hardness, S2 material has higher tensile strength and tensile modulus, finally S4 material has higher impact strengths then other glass fiber composites. Experimental investigation on Tribological properties of Flyash and silicon carbide reinforced Glass fiber epoxy composites with different weight(0%,2.5%,5%) percentages using pin-on-disc machine and analysis of tribological characterstics in ANOVA are done in this work. The results concluded that

In base material wear was influenced by factors speed followed by load and time.
In base material frictional force (FF) was influenced by factors Load followed by speed and time.
In base material coefficient of friction (CF) was influenced by factors speed followed by load and time.
In S1 material wear was influenced by factors time followed by load and speed.
In S1 material frictional force (FF) was influenced by factors Load followed by time and speed.
In S1 material coefficient of friction (CF) was influenced by factors load followed by speed and time.
In S2 material wear was influenced by factors load followed by speed and time.
In S2 material frictional force (FF) was influenced by factors Load followed by speed and time.
In S2 material coefficient of friction (CF) was influenced by factors speed followed by load and time.

XV. FUTURE SCOPE

Conduct vibration tests on these glass fiber reinforced composite materials

Conduct erosion tests on these glass fiber reinforced composite materials and the obtained results are predict by Artificial neural network(ANN) software.

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